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The AI-extended professional self: user-centric AI integration into professional practice with exemplars from healthcare

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Abstract
AI technologies are rapidly advancing and have shown potential for providing significant value across a variety of sectors, including healthcare. Much of research has focused on the technologies' capabilities and pushing their boundaries, with many envisioning AI and AI-enabled robots replacing human labor and humans in the near future. However, in critical domains of professional practice such as healthcare, full replacement is neither realistic nor aimed for, and collaboration between AI and humans is a given for the foreseeable future. This article argues for a shift away from a sole focus on the efficiency and effectiveness of technology, proposing instead that AI-enabled technologies increasingly should learn to adapt to human users considering that healthcare professionals already are overburdened. Rather than contributing to this burden, AI might extend the professional self by anticipating and supporting human needs and intentions. Drawing on a selective meta-synthesis of recent reviews and studies, this article introduces the concept of the *AI-extended professional self*. This concept suggests a temporary, dynamic integration of human professionals with AI that extends their capabilities with minimal additional burdens regarding training and application. Through three exemplars from healthcare—healthcare consultations, breast cancer screening, and robotic surgery—this article explores how a perspective rooted in the AI-extended professional self might unlock the potential for deeper AI integration into professional practice. Beyond these exemplars, this article calls for interdisciplinary research into the associated potential and challenges, advocating that the burden of AI integration needs to shift from humans to AI-enabled technologies.

Keywords Artificial intelligence · Extended self · Professional practice · Healthcare domain · Highlights

1 Introduction

Technologies enabled by artificial intelligence (AI) are rapidly advancing and have arguably reached the platform of productivity (Dedehayir and Steinert 2016), showing potential for and beginning to provide value across sectors to a wide variety of public and private organizations. One prominent such sector is healthcare, where AI is being touted as a revolution that is maximizing accuracy and efficiency while minimizing costs and human errors (Alowais et al. 2023).

Much of research on the application of AI-enabled technologies has focused on the technologies' capabilities and pushing their boundaries, with BigTech and policy- and decision-makers widely envisioning a world where AI and AI-enabled robots replace human labor and human agents in the near future. OpenAI board member Larry Summers (Catacora 2024) expects this replacement to start with entry-level jobs such as call center staff and social media content creators and rapidly expand to jobs relying on higher levels of expertise such as creative directors and software engineers.

However, in critical domains of professional practice such as healthcare, public service, and education, a full replacement of human agents in the near or even the foreseeable future seems unlikely due to both technical and regulatory limitations. In the domain of healthcare, full automation of practices such as diagnosis, prognosis, surgery, and pharmaceutical treatments is neither realistic (Ostrander et al. 2024) nor desired and aimed for (De Togni et al. 2024). To the

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contrary, for the foreseeable future, collaboration between AI and humans is a given (Jiang et al. 2024).

Considering that professionals such as healthcare professionals already are overburdened in many ways to begin with (Schneider-Kamp and Askegaard 2024), this article argues for a shift of the discussion on AI in professional practice away from a sole focus on the efficiency and effectiveness of technology. Instead of increasing the workload and mental load of human users who need to acquire new skills and depend on new forms of support (Jongsma et al. 2024), this article proposes to turn to a user-centric perspective for the development (Schneider-Kamp 2021) and integration (Jiang et al. 2024) of AI-enabled technologies, which increasingly should learn to adapt to human users rather than have the human users adapt to them. Rather than contributing to additional burdens for professionals, according to this perspective, AI might seamlessly extend the professionals' capabilities.

To develop this perspective, this article takes a two-pronged approach. As a first step, Sect. 3 reports on a selective meta-synthesis of recent articles on AI integration into professional practice with a focus on the healthcare domain. Building on the results of this meta-synthesis of 44 included articles from 2020 to 2024, Sect. 4 introduces the concept of the *AI-extended professional self*, where the *human user's capabilities are transparently extended by AI-enabled technologies that anticipate and support the human users' needs and intentions*. This concept suggests a temporary, dynamic integration of human professionals with AI that extends their capabilities with minimal overheads regarding costly training, support infrastructures, and time spent interacting with an artificial agent external to the workflow. The concept distinguishes itself from standalone AI systems along the dimensions of integration and adaptability, giving rise to a matrix of four levels of AI integration into professional practice.

As the second step, Sect. 5 of this article applies the four levels of AI integration to three exemplars from the healthcare domain: healthcare consultations, breast cancer screening, and robotic surgery. For each of these exemplars, after motivating and briefly summarizing the state of the art, this article explores how a perspective rooted in the AI-extended professional self might unlock the potential for deeper AI integration into professional practice. Beyond these exemplars, Sect. 6 reflects and concludes on the insights gained with a call for interdisciplinary research into the associated potential and challenges, advocating that the burden of AI integration needs to shift from humans to AI-enabled technologies.

2 Methods

In order to conceptually develop a user-centric perspective of AI integration into professional practice, we use an approach that is best described as a selective meta-synthesis. This approach leans on a number of closely related traditions, most notably qualitative meta-analysis (Dixon-Woods et al. 2006) and rapid reviews (Sadek et al. 2023). Our synthesis goal requires an interpretive rather than integrative synthesis (Dixon-Woods et al. 2005), focusing on the conceptual boundaries and recent shifts in the literature regarding AI integration.

We focus on healthcare as the context of professional practice and searched for articles using a number of thematically guided keyword searches in three databases: Google Scholar (for broad reach including conference proceedings), WebOfScience (for high-quality journal articles), and PubMed (for ensuring comprehensive coverage of the healthcare context). Table 1 provides an overview of the base keyword searches for each of the four themes: one regarding the AI integration into healthcare professional practice and three for the three exemplars constituting Sect. 5 (healthcare consultations, breast cancer screening, and robotic surgery).

Given how fast the cross-disciplinary research field of AI integration is moving, we used cutoff dates of 1 January 2020 and 31 December 2024. As the sheer number of results is overwhelming (in the thousands for each base keyword search), even with this limited period, an exhaustive screening approach was neither feasible nor necessary. To further narrow down candidate articles for inclusion, for each set of base keyword search results, we combined a temporal preference criterion with auxiliary keyword-based filtering covering different aspects relevant to our synthesis goal. The combination of base keywords and auxiliary keywords is reminiscent of Sadek et al.'s (2023) division of keywords into activity and target technology keywords, though with a temporal and iterative component.

Table 1 Overview of the base keyword searches used in PubMed syntax

Theme	Base keyword search
AI integration into professional practice	(healthcare) AND ((integrate) OR (integration)) AND (artificial intelligence)
AI in healthcare consultations	((healthcare consultation) OR (medical consultation)) AND (artificial intelligence)
AI in breast cancer screening	((breast cancer) OR (mammography)) AND (artificial intelligence)
AI in robotic surgery	(robotic surgery) AND (artificial intelligence)

Concretely, for a given auxiliary keyword filter such as "collaborative AI", we started screening candidate articles in reverse-chronologic order, beginning with the newest articles from December 2024 and identifying articles relevant to our synthesis goals. Whenever we included an article, we conducted a full-text review and coded and condensed it into a table of included articles. After each inclusion, we reflected on whether further articles on the same aspect would add substantial weight or we might discontinue the screening for further candidate articles for the given aspect and move to another combination of auxiliary keyword filter and base keyword search. Furthermore, we reflected on whether we needed to extend our list of auxiliary keyword filters based on the articles included so far. For review articles we further employed backward snowballing (Mourão et al. 2020), i.e., we identified further candidate articles from the references of the included review articles.

Finally, the results of reviewing the included article are compared and contrasted (Dixon-Woods et al. 2006). We then reflect on these findings to identify and structure current trends in (Pope et al. 2007) and the dimensions of AI integration into professional practice. Such structuring has the potential to reveal future trends and conceptual voids that facilitate the development of novel perspectives (Bearman and Dawson 2013).

3 Results on AI integration into professional practice

The iterative process of our selective meta-synthesis resulted in the inclusion of a total of 44 articles. The reviewing process is schematically explicated in Fig. 1.

The main codes and most important characteristics of these articles are summarized in Table S1 (provided as an appendix). The set of articles comprises 18 reviews, 19 empirical articles, six conceptual articles, and one mixed-methods study. The articles stem from multiple disciplines ranging from medical informatics and psychology to qualitative health research and various subfields of medicine. We note that many studies were conducted by interdisciplinary teams of researchers and practitioners. Figure 2 provides an overview of the publication dates and types of the included articles.

Several of the considered reviews showcase the capabilities of AI-enabled technologies, emphasizing their potential to revolutionize effectiveness and efficiency in general healthcare (Secinaro et al. 2021; Alowais et al. 2023) and particular subfields such as oncology (El Naqa et al. 2023), biomedical imaging (Khalifa and Albadawy 2024; Flory et al. 2024), and cardiology (Van den Eynde

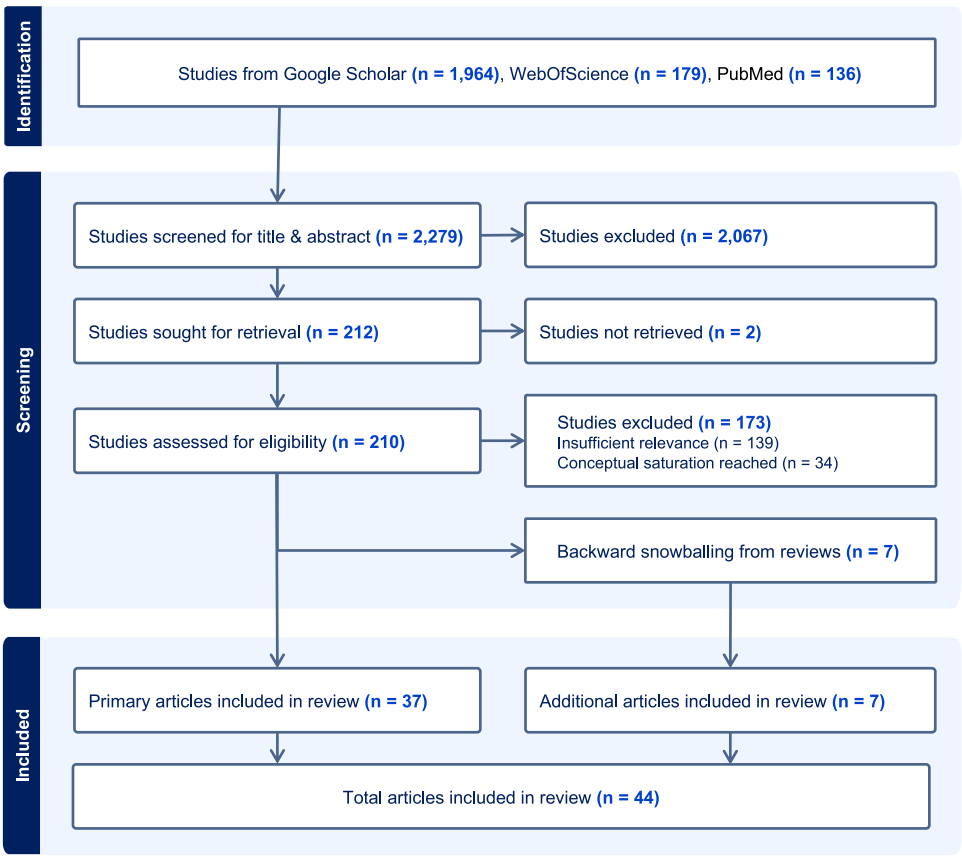

Fig. 1 Flow chart schematically explicating the review process

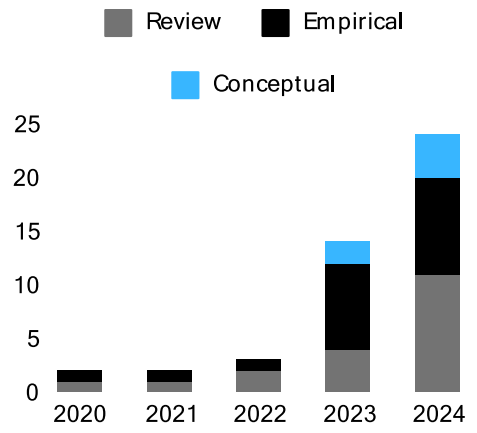

Fig. 2 Publication dates and types of the 44 included articles

et al. 2023). However, as our coding demonstrates, most articles emphasize that AI-enabled technologies should complement, augment, or supplement rather than replace human professionals.

Scholars have also begun to assess and highlight the pitfalls of employing AI-enabled technologies in domains of professional practice of critical societal importance. Most prominently, both reviews and empirical studies emphasized challenges regarding the integration into professional processes (Warmbein et al. 2023; Schneider-Kamp and Askegaard 2024), where AI-enabled technologies have to interact with healthcare professionals (and sometimes also patients) to achieve meaningful outcomes in terms of more efficient healthcare processes (Khalifa and Albadawy 2024) and improved healthcare outcomes (Dino et al. 2022).

As a response to such insights, the research field seems to be moving toward more collaborative approaches (Schleiger et al. 2024), where AI-enabled technologies present as artificial agents that collaborate with healthcare professionals (Dvijotham et al. 2023; Tanno et al. 2024) to ensure meaningful AI deployment (Schneider-Kamp 2021) and interaction with human agents (Jiang et al. 2024) and, ultimately, enhanced professional practice in the form of improved health outcomes (Sezgin 2023).

However, the reviewed literature also offered evidence that collaborative approaches typically imply additional burden to healthcare professionals (Jongsma et al. 2024), both regarding the time and efforts spent on training healthcare professionals (Monteith et al. 2024; Nair et al. 2024) to collaborate with the technologies and regarding the additional mental load and time consumption (El Naqa et al. 2023; Rasmussen et al. 2024) in clinical practice when having to interact with another agent. Essentially, the issue can be viewed as a dilemma rooted in the duality of the human and the artificial selves, where human and artificial agents represent fundamentally different intelligent agents (Monteith et al. 2024) that work from disparate internal world models, which they attempt to align and keep aligned using domain-specific or natural languages for anthropomorphic inter-agent communication (Kim and Im 2023).

Two commonly considered solutions to this dilemma are either closely integrating technologies into professional workflows (Secinaro et al. 2021; Zhang et al. 2024) or equipping artificial agents with the ability to adapt to the human user (Tanno et al. 2024; Jiang et al. 2024). In the former case, the closer technologies become integrated, the less mental load and time consumption can be assumed to be induced during the collaboration. In the latter case, instead of the human user learning how to effectively collaborate with the technology, the technology learns how to effectively assist the user.

4 Synthesizing the AI-extended professional self

Based on the insights from our selective meta-synthesis, this article argues that realizing the full potential of AI-enabled technologies in domains of professional practice such as healthcare in many cases likely requires combining these two solutions and moving further from full automation and collaboration to a state where the technology is both closely integrated and adaptive. In an extreme scenario where both full integration and user adaptation are achieved, the human and the artificial selves could be viewed as merged into a unified self. This article conceptualizes this as of yet mostly hypothetical state of full integration and user adaptation as the *AI-extended professional self*, where the *human user's capabilities are transparently extended by AI-enabled technologies that anticipate and support the human user's needs and intentions*.

The spectrum of the evolution of AI-enabled technologies in professional practice, ranging from fully-automated AI systems via collaborative AI solutions to the AI-extended professional self, is visualized in Fig. 3. This spectrum extends previous work, which often dichotomically opposes fully-automated systems with collaborative AI solutions (Sezgin 2023).

Theoretically, the paradigm of the AI-extended professional self builds upon Russell Belk's seminal

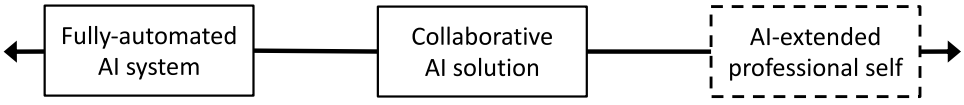

Fig. 3 Spectrum of the evolution of AI-enabled technologies

conceptualization of the *extended self*, where possessions such as inanimate objects, technologies, and relations shape human agents' identities (Belk 1988). A human agent and their possessions form a unit that extends the self of the human in relation to their environment, equipping the human agent with capabilities it otherwise would not have. More recent work has investigated the applicability of the concept of the extended self in the context of digital technologies and the interactions with human and artificial agents (Belk 2016). The AI-extended professional self relies on the integration of AI into a professional's cognitive and motor processes, amplifying the human agent's abilities much like other identity-providing possessions or relationships.

The concept of the AI-extended professional self represents a move away from a narrow focus on the capabilities, efficiency, and effectiveness of AI systems and turns the perspective by a full 180°, rather taking its onset in the capabilities, needs, and intentions of the human user. In other words, the concept provides a way of moving the discussion from a technology-centric model of healthcare to a human-centric one (Aquino et al. 2023). Consequently, this article argues for a vision of AI in professional practice that is completely juxtaposed with visions of replacing humans with AI based on neoliberal logics of economic efficiency.

Rather, this article takes its onset in the observation that care cannot be provided by technology alone but is an emergent property of human and non-human agents (Schneider-Kamp and Fersch 2021). Based on this observation, it argues that logics of care (Schneider-Kamp and Askegaard 2021) compel us to focus on exploiting technological advancements toward closer integration into professional workflows and higher levels of adaptability to extend the selves of professionals. This has the potential to increase their effectiveness and simultaneously reduce their mental load and time consumption, ultimately yielding improved healthcare and healthcare outcomes.

Conceptually, the AI-extended professional self presupposes that human professional users form assemblages of their professional capabilities with the ones of the artificial agent to solve concrete professional challenges (Schneider-Kamp and Fersch 2021). These assemblages of human users and AI-enabled technologies are latent (Schneider-Kamp and Askegaard 2022) as they form as parts of professional workflow and remain dormant outside of these workflows. While these assemblages may only be activated for a relatively limited time as required by particular professional workflows, in between the activations the AI-enabled technologies latently memorize previous interactions with, the preferences of, and any insights they have learned about the needs and intentions of human professionals. Furthermore, these assemblages can be viewed as constituting temporary cyborgs, i.e., professional agents with superhuman capabilities that are rooted in the hybridity of a human and an artificial agent (Aquino et al. 2023).

The AI-extended professional self stands in opposition to the standalone AI system that acts as an autonomous agent without collaborative efforts. The differences run along the dimensions of workflow integration and user adaptivity, with standalone AI systems being external to professional workflows and without user adaptivity while the AI-extended professional self is rooted in a close integration of adaptive AI-enabled technologies into the workflows. These two dimensions span a continuum that can be differentiated into four levels of AI integration into professional practices that Fig. 4 visualizes.

In addition to *standalone AI systems* in the lower-left quadrant and the *AI-extended professional self* in the upper-right quadrant, the upper-left quadrant features *adaptive AI agents* that anticipate and support human users' needs and intentions while the lower-right quadrant is comprised of *integrated AI systems* designed to function as intrinsic elements of professional workflows.

The *standalone AI system* works independently and extrinsic to the workflow of the (healthcare) professional. It produces results that subsequently are to be reviewed by human professionals. Interactions between the human and AI workflows are typically limited to providing data to the AI system and to reviewing its results. As an example, consider automated mammogram analysis (Yoon et al. 2023), where an AI model automatically analyzes mammography images to detect abnormal tissue patterns indicative of breast cancer tumors. Such a system is rigid as it lacks the ability to adapt varying needs of the human user and it is extrinsic, as the workflows only interact at the end of the AI workflow for manual review.

The *adaptive AI agent* remains extrinsic to the professional workflow but adapts to the human user. Its results are influenced by the AI's anticipation of the user's needs and intentions based on an ongoing interaction between human and artificial agents. As an example, consider a chatbot based on a large language model (Lautrup et al. 2023) that provides interactive support in diagnostic processes by suggesting potential (differential) diagnoses and diagnostic follow-up steps (Hirosawa et al. 2023) based on information and context provided by a healthcare professional. Such a system is adaptive but external to the primary workflow of the professional, necessitating interruptions of the primary workflow to engage in a secondary collaborative workflow with the AI agent.

The *integrated AI system* is closely embedded into professional workflows but remains rigid. The results are presented as part of the primary workflow of the human users but follow a non-adaptive inflexible scheme. As an example, consider an augmented reality system that enhances the healthcare professional's field of view with vital patient

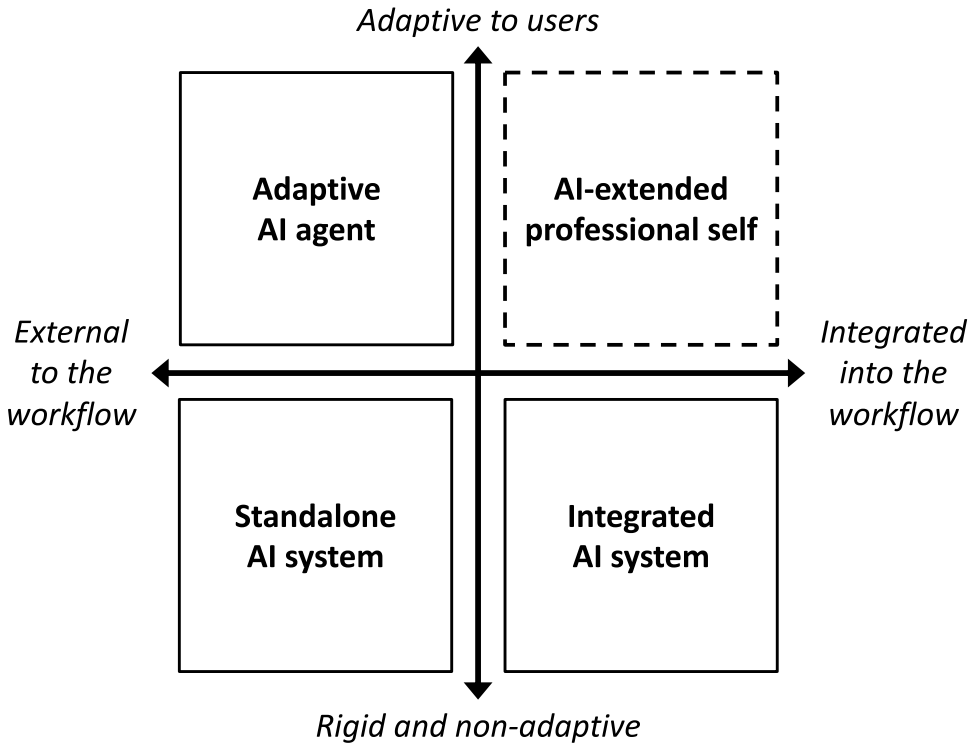

Fig. 4 Levels of AI integration in professional practice

information (Tanbeer and Sykes 2024) such as pulse, blood pressure, oxygen levels, and a bullet point summary of the electronic health records (Pavuluri et al. 2024). Such a system is closely integrated as it provides information to the professional without breaking the primary workflow. However, it is rigid as the information shown is pre-determined and the system does not adapt to the changing needs of the human user such as requests for more detailed information on current medication based on the ongoing exam.

The *AI-extended professional self* represents the paradigm proposed in this article. Here, the AI-enable technology is transparently integrated into the professional workflow and highly adaptive to the human user. The results are co-produced as the technology effectively functions as an extension of the professional's cognitive and motor processes. As an example, consider a robotic surgery system (Fosch-Villaronga et al. 2023), where the AI continuously adjusts its actions and recommendations based on live data and the actions of the surgeon, letting the human professional and the artificial agent act as a unified system. Such a system would be both integrated and adaptive, providing superhuman surgical capabilities.

5 Exemplars from the healthcare domain

Leveraging the concept of the AI-extended professional self and applying the levels of AI integration into professional practice as a guiding lens, this section carves out the relevance of a user-centric perspective by diving into three exemplars from healthcare professional practice where AI solutions have been and are being implemented widely: healthcare consultations; breast cancer screening; and robotic surgery. For each exemplar, the corresponding subsection motivates the exemplar and briefly surveys the state-of-the-art with respect to the levels of AI integration before investigating how the paradigm of the AI-extended professional self might contribute to unlock further potential of AI integration into professional practice.

5.1 Healthcare consultations

Healthcare consultations between patients and healthcare professionals present one of the pillars of professional practice for most healthcare professionals. One of the most pressing problems in this context is the limited time that may be allocated per patient. Estimating from a systematic review of primary care physician consultation times, approx. 50% of the world population lives in countries where the physician spends 5 min or less on average per consultation (Irving et al. 2017). Even in most high-income countries, the average consultation time typically varies between 5 and 15 min per patient (Irving et al. 2017).

Unsurprisingly, the rise of conversational AI agents (Lautrup et al. 2023) has sparked interest in how these systems may address the time limitations of healthcare professionals. Many solutions aim to replace traditional healthcare consultations with human healthcare professionals by virtual

healthcare consultations with chatbots (Loh et al. 2024) that are cheaper, available around the clock, and not limited by the number of qualified professionals available (Alowais et al. 2023). Other solutions aim at filling the voids between traditional consultations by virtual ones, most prominently with regard to effecting lifestyle changes (Chen et al. 2024), or preparing patients before consultations (Hussain et al. 2024). Conversational agents are also employed to offload administrative tasks such as transcribing consultations and summarizing treatment plans (Pavuluri et al. 2024).

Throughout the reviewed literature, the AI-enabled chatbots were integrated as more-or-less adaptive AI agents external to the primary workflow of the healthcare professionals during healthcare consultations. Such AI agents have been ranked lowest among user preferences for face-to-face, virtual, and AI-based consultations (Mayer et al. 2024). The use of such chatbots as an integrated part of the workflow during healthcare consultations has been investigated using Wizard of Oz-style prototyping (Ren et al. 2020), finding the need for a balance between prompting and proactivity. Different ways of supporting healthcare professionals during consultations have been investigated qualitatively, ranging from silent digital experts to communicative ones (Färber et al. 2024).

Following the paradigm of the AI-extended self, one might conceive an AI solution extending Ren et al.'s (2020) vision. Such a solution might listen in on the conversation between healthcare professional and patient, following with the content of the conversation and drawing upon external data sources such as electronic health records, imaging data, and laboratory results. This AI solution could make the healthcare professional aware of information and provide advice when and where it makes sense, i.e., situationally and contextually. It might also suggest ways of obtaining further information, ranging from questions directed toward the patient to diagnostic recommendations. The degree to which the healthcare professional acknowledges and employs the provided information, advice, etc. would provide feedback that allows the AI-enabled technology to adapt to the users' preferences, needs, and intentions.

While AI solutions with these capabilities have to the best of our knowledge yet to be developed, the foundational technology that might support such solutions is maturing at a rapid pace. Multimodal large language models that can deal with real-time voice input (Li et al. 2023; Huang et al. 2024) present a possible emerging technology that might be employed for an AI-driven extension of the professional inner monologue. However, currently, the main challenges would lie in ensuring the validity and reliability of the information and advice provided, particularly considering that language models are prone to hallucinations in spite of mitigating attempts (Ji et al. 2023). In a more distant future, brain-computer interfaces (Maiseli et al. 2023) might support supports professionals in "remembering" and "knowing" all the relevant information and advice without a need for conscious interaction.

5.2 Breast cancer screening

Breast cancer screening is a crucial element of cancer prevention efforts, with breast cancer accounting for approx. 30% of cancers in women and taking a top spot among all cancer forms (Loibl et al. 2021). At the same time, breast cancer screening based on a combination of mammography with ultrasonic imaging, MRI, and/or biopsies has been shown to reduce mortality by approx. 20% (Loibl et al. 2021), making it a hallmark of preventive screening programs. Screening programs are commonly challenged to deliver diagnostic results quickly given the sheer volume of patients, typically resulting in significant waiting times from first suspicion to final diagnostic result that act as a significant stressor for the women involved (Sweeny et al. 2019).

AI solutions for imaging-based diagnosis have been found to exhibit detection rates similar to or exceeding those of human experts in several fields (Khalifa and Albadawy 2024) with the potential to reduce time to assessment significantly. Such solutions have shown promise in analyzing both mammograms (Yoon et al. 2023) and ultrasound images (Yoen and Chang 2023), exhibiting detection rates similar to or exceeding those of human experts (Khalifa and Albadawy 2024) with the potential to reduce time to assessment significantly. However, these systems are often highly specialized, typically focusing on one modality such as mammography or ultrasonic image at a time. While the role of AI-enabled technologies currently mostly is concerned with efficiency and accuracy through fully-automated image analysis, advancements are being made regarding the integration of multi-omics data and the provision of predictions for diagnosis and prognosis (Zhang et al. 2023).

Virtually all the AI solutions from the reviewed literature should be characterized as standalone AI systems, as they typically function externally to the professionals' workflow. Large-scale retrospective cohort studies clearly indicate that AI solutions currently are not ready to be deployed without human involvement (Marinovich et al. 2023). The burden of deciding whether and which supplemental examinations to perform and the final diagnostic decision-making remain firmly with the healthcare professional (Zhang et al. 2023). This diminishes the real-world impact of AI on the workload of medical imaging professionals, radiologists, and oncologists, a workload that in principle might be reduced by 68.3% (Xavier et al. 2024).

Drawing on the concept of the AI-extended professional self, a more integrated and adaptive approach would have the AI not only analyze mammographic and ultrasound data but also make recommendations for supplemental examinations.

The AI might further provide active guidance during supplemental examinations of the screening program. For example, it might guide the sonographer during an ultrasound examination. The AI system might overlay mammographic data onto the live ultrasound feed in real time. In this way, the medical imaging professional would obtain a dynamic multimodal view of the breast tissue under examination. What is more, the AI could highlight potential areas of abnormal tissue identified during mammography, effectively guiding the attention of the professional to the most relevant areas. Conversely, in the spirit of Schleiger et al.'s (2024) work, the AI system would be able to incorporate implicit feedback based on the diagnoses and treatment decisions made, as well as explicit feedback from professional users.

While such fully integrated systems are still in development (Zhang et al. 2023), rapid progress in real-time multimodal machine learning models puts the required technologies within grasp in the near future. The main challenges can be expected to revolve around the user interface and facilitating a good-enough balance between processing time restrictions imposed by the real-time scenario and the accuracy of the results. Similarly to the healthcare consultations, the acceptance among and the adaptation to the involved groups of professionals would represent another obstacle to overcome.

5.3 Robotic surgery

Robotic surgery has proven its transformative potential, increasing precision, reducing recovery times, and enabling minimally invasive procedures even in difficult surgical fields such as the head and the neck (Goh and Ali 2022). Since its inception in the 1980s, robotic surgery has extended healthcare professionals' capabilities with superhuman accuracy, facilitating complex delicate procedures previously considered impossible (Wedmid et al. 2011). Systems with flexible robotic arms that can be equipped with different surgical instruments and are operated by human surgeons have been the state of the art since the early 2000s (Knudsen et al. 2024). State-of-the-art systems still require highly-skilled surgical assistants in the surgical field (Zhang et al. 2024) and incur high costs regarding the training and maintenance of surgeons' skills (Chen et al. 2020).

Some AI solutions have been used to assess the skills of surgeons during or after the surgery (Knudsen et al. 2024), often providing feedback that can be used as part of surgical education (Zhang et al. 2024). Other applications of AI include real-time assessment of the surgical field and optimization of instrument choice and operation (Iftikhar et al. 2024). Taking automation to the next level, numerous advancements are being made in automated suturing (Ostrander et al. 2024). Full automation of robotic surgeries is not considered likely or desirable (Zhang et al. 2024).

The current integration of AI solutions into robotic surgery in the reviewed literature is often external to the primary workflows and rigid rather than adaptive, with the ability of such solutions to identify critical tasks and provide meaningful feedback remaining limited (Moglia et al. 2021). While AI-enabled technologies are integrated into the robotic surgery system and the surgical workflow, they typically are assigned passive roles providing feedback on the surgeon's or the surgery's process (Knudsen et al. 2024). Some of the more recent advancements move the level of AI integration from standalone AI systems to integrated AI systems, with AI providing real-time information (Iftikhar et al. 2024) and automating routine elements of the surgical workflow (Ostrander et al. 2024). Other recent advancements such as the anticipation of instrument choices (Iftikhar et al. 2024) propel the level of AI integration for a limited part of the surgical workflow to that of adaptive AI agents.

Striving for the paradigm of an AI-extended professional self in robotic surgery might yield an AI system that not only enhances the accuracy of the surgery but also adapts in real-time to the often less-than-predictable surgical process. Combining and extending on some of the most advanced developments mentioned above, such an AI system would not only provide real-time information but also provide recommendations for surgical decision-making by drawing on previous surgical situations by the same or different surgeons and integrating with peripheral information such as the vital values of the patient. The AI would learn the preferred techniques of the operating surgeon and adaptively anticipate the instruments to be used in the next steps, reducing the mental load of the human surgeon and enhancing surgical flow. Furthermore, based on its faster ability to analyze the surgical field the system could guide decision-making in the case of unexpected complications.

The AI-enabled technologies required to realize such an AI-extended professional self in robotic surgery are still a subject of active research and development. Many of the components needed are already available at a proof-of-concept or prototype level, though, speaking to the principal feasibility of such a system (Ostrander et al. 2024; Iftikhar et al. 2024; Zhang et al. 2024). The main challenge will likely be to integrate the numerous AI-enabled technologies that, for example, assess the surgical field, automate routine tasks, provide peripheral information, and aid decision-making into a coherent system. And, particularly, to balance the desire for transparency of the integration with the availability of all this functionality for the surgeon as the professional in charge of the primary workflow.

6 Concluding remarks and directions for future research

Through selective meta-synthesis, we reviewed and synthesized a sample of 44 included articles. The sample demonstrated a general understanding of the need for more seamless integration of AI into professional workflows as part of the quest to realize the workload reduction potential of AI-enabled technologies. Our review and coding of the sample also demonstrated that such technologies need to be better able to adapt to the needs of the professionals. Based on these insights, we introduced the concept of the AI-extended professional self to fill the conceptual void at the nexus of simultaneously integrated and adaptive collaborative AI systems.

The concept of the AI-extended professional self presents a shift from technology-centric models of professional practice to user-centric ones, where integrated and adaptive AI solutions draw upon Generalist Medical AI (Moor et al. 2023) to extend the capabilities of professionals as seamlessly as possible. As of yet, though, such fully integrated adaptive systems remain out of grasp when relying on current state-of-the-art technologies. While many of the AI-enabled technologies essential for realizing important ingredients of the AI-extended professional self are advancing on several fronts (Li et al. 2023; Zhang et al. 2023; Ji et al. 2023; Ostrander et al. 2024; Iftikhar et al. 2024), it is difficult to predict the pace and scale of these research and development endeavors and estimate a timeline for their integration.

Beyond the need for further maturing of the technological capabilities of AI, the concept of the AI-extended self faces further limitations and obstacles. One of these is that independent of the value proposition, any technology that invades so intimately into the professional workflow can be expected to meet resistance from human professionals (Ren et al. 2020; Färber et al. 2024; Rasmussen et al. 2024). Besides fears of eventual replacement, professionals might be worried about the potential for the deskilling of professionals (Ergin et al. 2022; Schneider-Kamp and Askegaard 2024) or simply resist the idea of engaging in assemblages with technology that effectively turns them into temporary cyborgs (Aquino et al. 2023; Ponlatha and Sumathi 2024).

There is also reason to critically examine where pursuing the paradigm of the AI-extended professional self is warranted. In resource-constrained environments such as remote healthcare in rural areas (Ramachander et al. 2025), supplementation in situations of severe understaffing (Anisha et al. 2024), or in disaster response (Kasinathan et al. 2024), fully-automated standalone AI system might provide significant value as part of best-effort solutions to healthcare needs. In other situations, collaborative approaches relying on adaptive AI agents or integrated AI systems might suffice to meet the needs. The resource consumption and effort needed to develop, deploy, operate, and maintain solutions at the level of the AI-extended professional self might incur prohibitive resource consumption (Khalifa and Albadawy 2024) in situations where the urgency and volume—and by extension the potential for impact—are significantly lower than for the three exemplars from Sect. 5.

Any real-world implementation of the AI-extended professional self can be expected to encounter trust issues. Here, trust refers not only to trust in the effectiveness of the AI but also to an accountable distribution of responsibility (El Naqa et al. 2023), where questions around shared decision-making and the attribution of blame in the case of errors (Fosch-Villaronga et al. 2023) need further investigation. Trust also requires aligning the evaluations of human and AI performance with best practices of the field, ethical and regulatory guidelines, concerns about patient safety, and last but certainly not least, the health outcomes for patients.

Future research is needed to address these issues and will require interdisciplinary teams of researchers and practitioners to drive the field of AI integration in professional practice forward. Beyond the domain of healthcare, scholars might also investigate the concept of the AI-extended professional self as a lens for AI integration in other domains of professional practice such as law enforcement (Davies and Krame 2023) or education (Chiu et al. 2023), where a user-centric focus likewise might contribute to improved integration and societal value generation.

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Declarations

Competing interests The authors declare no competing interests.

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